EXTRACT FROM MINES & PETROLEUM REPORT, 1969

THE GEOLOGY OF THE OWEN LAKE AREA

AND

DIAMOND BELL

PP 122-141

by

B.N. CHURCH

BARR, LYBDENUM (No. 477, Fig. 13)

LOCATION: Lat. 54° 26′ Long. 126° 52′ (93L/7W)
Between elevations of 2,400 and 3,700 feet 4 miles west of Barrett.
CLAIMS: One hundred and seventy-three, including the BARR, LYBDENUM, BA, LB, CU, and MAG claims.
ACCESS: By 14 miles of road from Quick, on Highway No. 16.
OWNERS: BARR and LYBDENUM claims owned by W. H. Smith, Telkwa; remainder owned by operator.
OPERATOR: FORTUNE CHANNEL MINES LTD., 500, 890 West Pender Street, Vancouver 1.
METALS: Molybdenum, copper.
WORK DONE: Three men spent one and one-half months on the property soil sampling and conducting a magnetometer survey.
REFERENCES: *Minister of Mines, B.C.,* Ann. Repts., 1966, p. 103; 1968, pp. 137, 138; Assessment Reports Nos. 1139, 2308, and 2309.

DOT, ROD, TON, LUKY (No. 439, Fig. 13)

LOCATION: Lat. 54° 19′ Long. 126° 38′ (93L/7E)
Between elevations of 2,600 and 2,900 feet at junction of Bob Creek and Buck River.
CLAIMS: DOT 3 to 5, TON 1 to 8, ROD 4 and 6, LUKY 1 to 40, formerly known as GOLD BRICK.
ACCESS: By road from Houston, a distance of 10 miles.
OWNER: Lorne Hansen.
OPERATOR: AMERICAN SMELTING AND REFINING COMPANY, 535 Thurlow Street, Vancouver 5.
METALS: Gold, silver, zinc.
WORK DONE: Three men spent half a month on the property prospecting and sampling. P. G. Curtis, geologist, supervised the work.
REFERENCES: *Minister of Mines, B.C.,* Ann. Rept., 1968, p. 138; *Geol. Survey, Canada,* Paper 40-18, p. 17.
DESCRIPTION: Pyrite, sphalerite, and galena occur as disseminations in volcanic rocks.

OWEN LAKE

THE GEOLOGY OF THE OWEN LAKE AREA

By B. N. Church

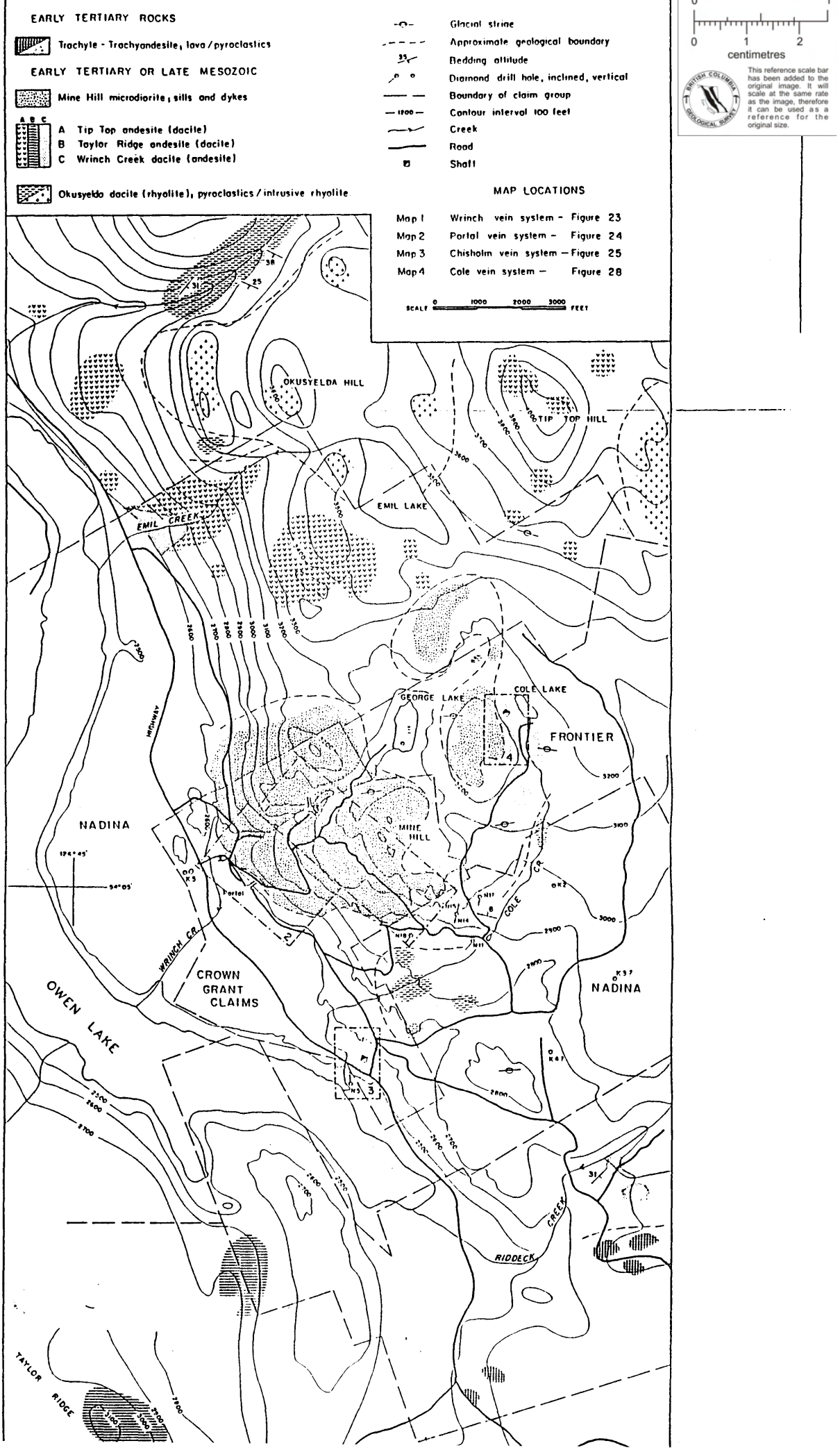
Introduction

The Owen Lake area has been the scene of prospecting activity since 1912 when vein mineralization was discovered along Wrinch Creek just east of Owen Lake. Nadina Explorations Limited and Frontier Exploration Limited have reactivated the old Silver Queen and Diamond Belle prospects in the area and Nadina now appears to be on the verge of production. This report is intended to amplify the regional geology of the area and update detailed geological information now available on these properties.

Physiography

The Owen Lake map-area is near the west margin of the Nechako plateau on the divide between the Skeena and Fraser River systems (*see* Fig. 21). The topography is typically rolling, with maximum relief of only about 1,800 feet. Slopes

GEOLOGY OF THE OWEN LAKE AREA



increase gently from Owen Lake, at an elevation of 2,410 feet, to the highest points, Okusyelda Hill and Tip Top Hill, at about 3,600 feet and 4,000 feet respectively near the north boundary.

The area is well forested except for meadows on south-facing slopes at high elevations and immediately around Mine Hill, in the central part, which is almost entirely open grassland even at relatively low elevations.

Bedrock exposure in the region is poor, being less than 10 per cent of the total area. Commonly only the most resistant rocks crop out even on hills and ridges. A blanket of alluvium locally more than 20 feet thick covers the slopes of Mine Hill, and overburden in excess of 100 feet thick was encountered in drill-holes on the large meadow to the southeast.

General Geology

The Owen Lake area is underlain mainly by an " old series " of lava and pyroclastic rocks of either late Mesozoic or early Tertiary age and a small area of " young series " Tertiary volcanic rocks which are probably the local equivalent of the Ootsa Formation (Eocene?). These rocks are cut by stock-like igneous intrusions, sills, and dykes.

Old Series Volcanic Rocks and Intrusions (Late Mesozoic or Early Tertiary)

The composition distribution of the old series volcanic pile is shown on Figure 22. The most common rocks are dacites and dacitic andesites. Basaltic andesite and rhyolite are scarce and no basalt was found. The local names " Okusyelda dacite," " Wrinch Creek dacite," " Taylor Ridge andesite," " Tip Top andesite " are informally applied to the main stratigraphic units of the old series.

The Okusyelda acid volcanic beds and related intrusions are thought to be the oldest rocks in the exposed succession. The main eruptive centres are on Okusyelda Hill and the small knoll immediately east of Tip Top Hill. The intrusive rocks underlying these areas are distinctively light coloured and locally show fluxion texture. The rocks contain about 20 per cent plagioclase phenocrysts and accessory biotite and quartz crystals. These minerals are commonly set in a fine-grained matrix.

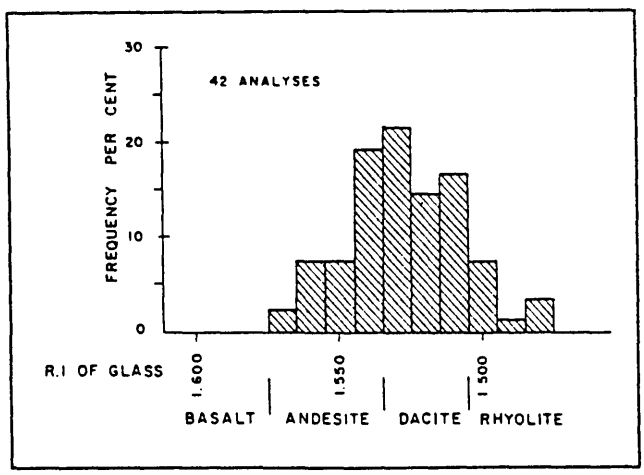


Figure 22. Frequency distribution of volcanic rocks in the Owen Lake area.

Quartz-bearing pyroclastic rocks are exposed in Okusyelda Creek and southeast of Mine Hill along much of the course of Cole Creek. The rocks are characterized by an abundance of white porcelain-like fragments and small corroded quartz crystals displayed in thin-section. The dominant phase exposed in Okusyelda Creek is tuff breccia, with some intercalated accretionary lapilli and thin volcanic sandstone and siltsone beds. These beds dip 25 to 40 degrees to the south.

Rhyolite and rhyodacite pyroclastic rocks exposed along Cole Creek are severely altered, the feldspathic and lithic fragments having undergone marked kaolinization. The rocks are enriched in pyrite and normally carry accessory carbonates. Generally quartz is unaffected by the alteration and the original embayed and corroded outlines of quartz phenocrysts are still visible in thin-section. The attitude of the acid pyroclastics near Cole Creek has been determined from data obtained from diamond-drill holes. The intersections of these drill-holes with the top of the acid pyroclastic unit indicate that the bedding attitude strike is 105 degrees and dip 8 degrees northeast.

The Wrinch Creek volcanic member, which appears to be contemporaneous or slightly younger than Okusyelda rocks, is composed of dacite and andesite volcanic fragmental rocks. This unit is exposed in Wrinch Creek, near Cole Lake, on the southwest side of Mine Hill near the 2,800-foot elevation, in the Chisholm shaft area, and at the mouth of Emil Creek. Typically, the rocks are highly altered and vary in colour from light grey to dark brown, consisting mostly of massive volcanic breccia (*see* Plate VB). In thin-section these rocks consist mainly of a fine-grained mixture of kaolin and quartz, minor carbonate minerals, and disseminated pyrite grains.

The Tip Top andesite, Taylor Ridge andesite, and Mine Hill microdiorite together form the most widespread and important geological units in the area. The rocks are petrographically similar and therefore they are thought to be the same age.

The Tip Top andesite covers much of the northern part of the map-area. The rocks consist of brown porphyritic lavas and pyroclastic beds which clearly overlie the acid volcanic suite at Tip Top Hill and in the Emil Creek area. The rocks are usually distinctive in hand-specimen, being charged with small white feldspar laths 1 or 2 millimetres long and a few large prismatic hornblende crystals measuring as much as 1 centimetre long. In thin-section these rocks are characteristically merocrystalline with subhedral plagioclase, pyroxene, and hornblende phenocrysts suspended in very fine-grained matrix. Modal analysis shows 40 per cent fresh oscillatory zoned plagioclase, 7 per cent combined altered pyroxene and hornblende, accessory biotite and magnetite, and 50 per cent matrix. Close examination shows small quartz grains in the matrix of some of these rocks.

The Taylor Ridge andesite, lying southwest of Owen Lake, is remote from the type area of Tip Top andesite; however, it is believed that these units were once co-extensive throughout the Owen Lake area.

The old series volcanic rocks are intruded by the "Mine Hill microdiorite" at the centre of mineralization on the Nadina and Frontier properties on Mine Hill and in the area between George Lake and Cole Lake. This intrusion is sill-like in form, covering an area of scattered outcrops about 1 mile in diameter. Windows are eroded through the sill in the vicinity of George Lake and in the canyon of Wrinch Creek. The sill appears to be thickest south of Wrinch Creek on Mine Hill where fresh microdiorite feeder dykes have been intercepted in trenches and underground workings on the Nadina property. Much of the microdiorite exposed on Mine Hill is fresh, black, or dark grey, and magnetically sensitive to a tack finder. The rock is generally brittle and charged with small feldspar crystals and a few biotite books. In thin-section the rock is crowded with rectangular plagioclase plates 1

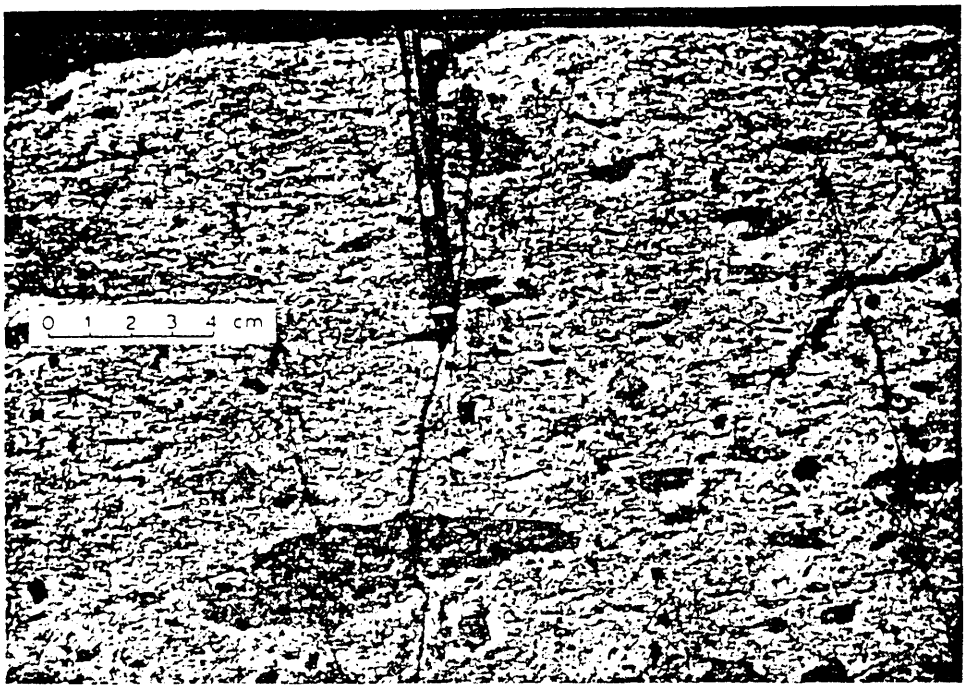


Plate VA.—Rhyodacite ash-flow bed containing a collapsed pumice fragment (fiamme), near the head of Denys Creek, Dominion Basin.

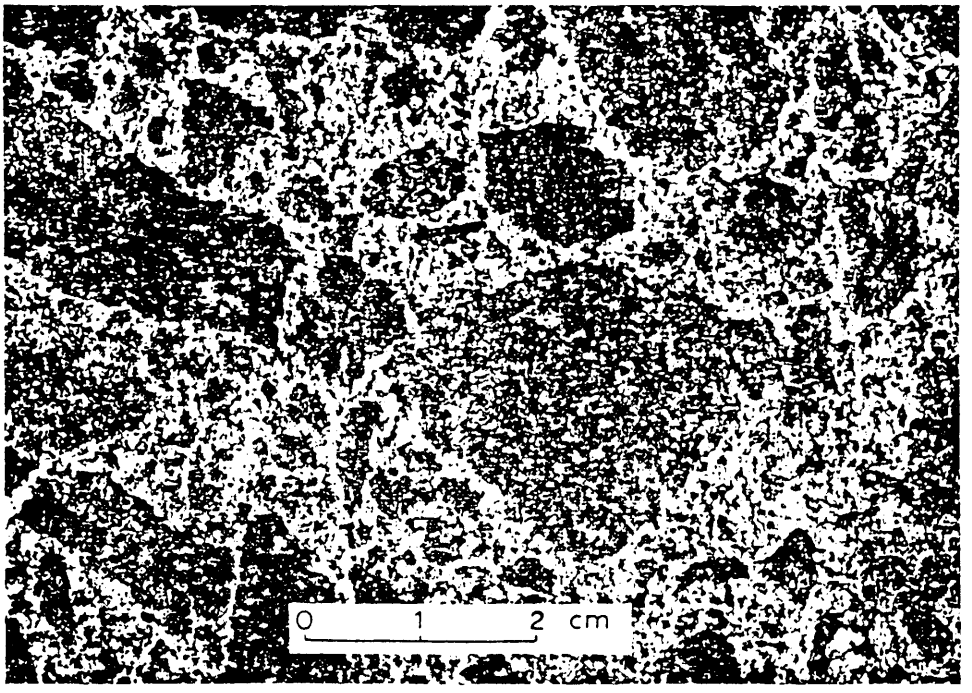


Plate VB.—Owen Lake area, dacitic andesite volcanic breccia near Cole Lake.

to 3 millimetres in diameter, small interstitial pyroxene subhedra, one-half to 1 millimetre in diameter, and a few books of biotite one-half to 4 millimetres across, disseminated magnetite grains, and usually fine-grained groundmass. In some specimens the interstitial areas between feldspars is filled with wedges and angular grains of quartz. Chemical analysis of a fresh sample of microdiorite from Wrinch Creek is similar to Daly's average augite andesite (*see* Table of Chemical Analyses, p. 138). The microdiorite is generally altered along fissures and where it forms the wallrock of veins. The feldspar is usually kaolinized and ferromagnesian constituents are replaced in part by fine-grained carbonates, epidote, and pyrite, the altered rock being characteristically non-magnetic. In a few places very close to veins the rocks are markedly chloritized.

Young Series Volcanic Rocks and Intrusions (Tertiary)

The main exposures of Tertiary (Eocene?) volcanic beds are in the southeast part of the map-area. The rocks consist of fresh trachyte and trachyandesite lavas and pyroclastics. A section of light-grey aquagene tuff about 150 feet thick is exposed in the canyon of the east fork of Riddeck Creek near the east boundary of the map-area (*see* Plate VIA). These beds strike about 045 degrees and dip 30 degrees south. A large area south of Riddeck Creek is underlain by trachyandesite lava. In the few places of good exposure the lava is found to be medium brown or grey, vesicular, with few phenocrysts, and commonly zeolite-bearing.

Beds of similar alkaline volcanic rocks are known to extend to the east and it is certain that the same units once blanketed the central part of the map-area. Pulaskite and trachyte feldspar-porphyry feeder dykes are found throughout the underground workings and surface working on Mine Hill and in the nearby areas.

A few young basalt dykes also occur in the Mine Hill area. These are thought to be related to the plateau basalt lavas (Endako Formation of Miocene ? age) cropping out on the ridge tops and buttes east of the Owen Lake area.

SILVER QUEEN (NADINA) (No. 462, Fig. 13)

By B. N. Church

LOCATION: Lat. 54° 05′ Long. 126° 43.8′ (93L/2W, 2E)
(Portal of Earl adit)

The mine workings are just east of Owen Lake, 27 miles by good all-weather gravel road south of Houston.

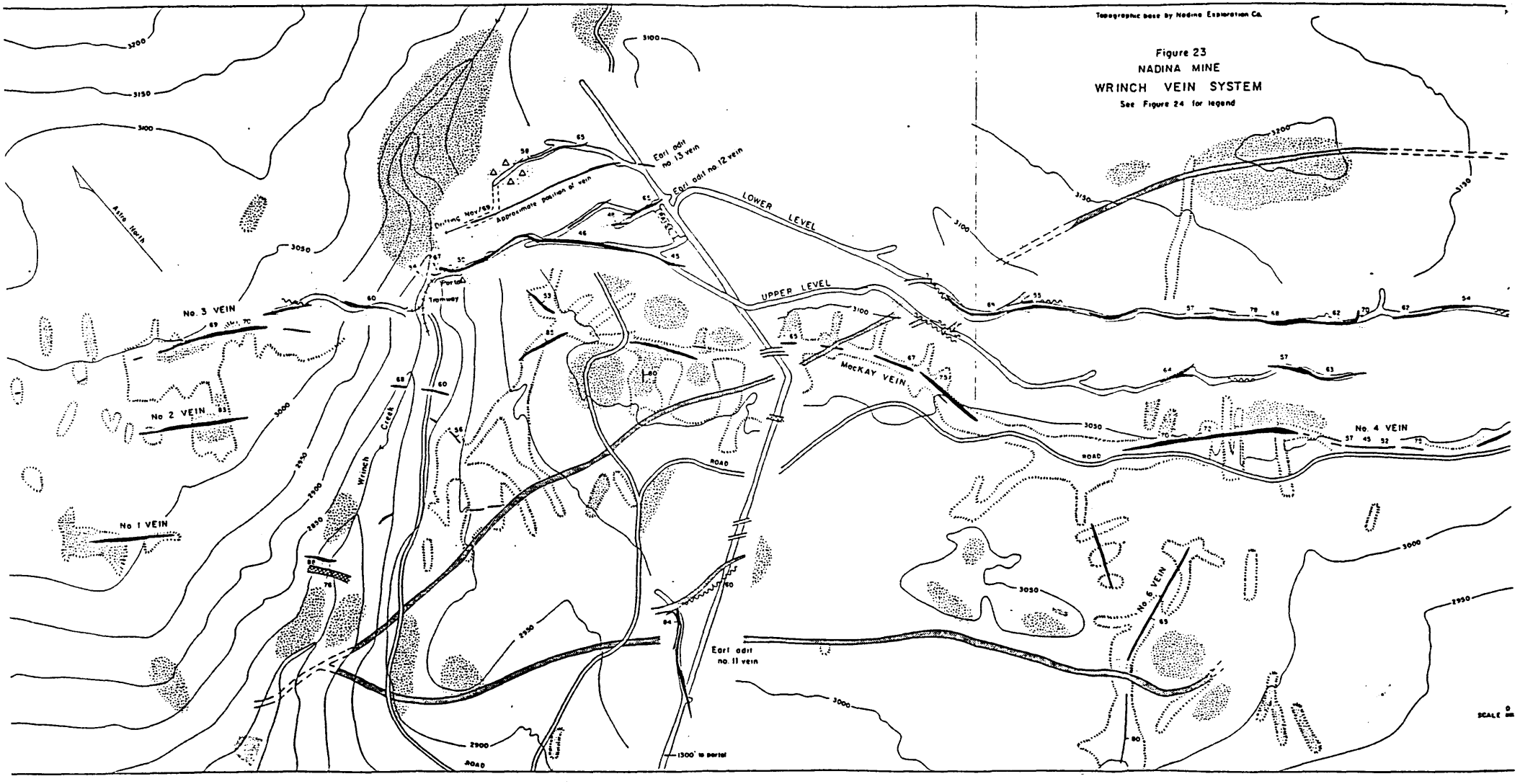
CLAIMS: Seventeen Crown-grant claims; EARL 1 to 3, EARL 1 FRACTION, SILVER QUEEN, SILVER KING, SILVER TIP, TYEE, I.X.L., I.X.L. 3, LUCY, LILI FRACTION, MARY, MARG FRACTION, MAE, MAE 1. Eighty-five claims held by location; NADINA 1 to 4, OWL 1 to 15, OWL 1 FRACTION, ANGUS 1 to 4, CU FRACTION, AG FRACTION, M3 FRACTION, OL 1 to 22, 25, 26, BIG MOOSE 1 to 10, HAWK 1 to 9, T.J. 1 to 3, 5, DOUBLE X 1 to 12.

ACCESS: The mine and east claim block is serviced by the Houston–Francois Lake road. Numerous company roads and farm roads provide excellent access to most parts of the property east of Owen Lake.

OWNERS: The seventeen Crown-granted claims are held under agreement with Canadian Exploration Limited and the eighty-five recorded claims are owned by Nadina Explorations Limited.

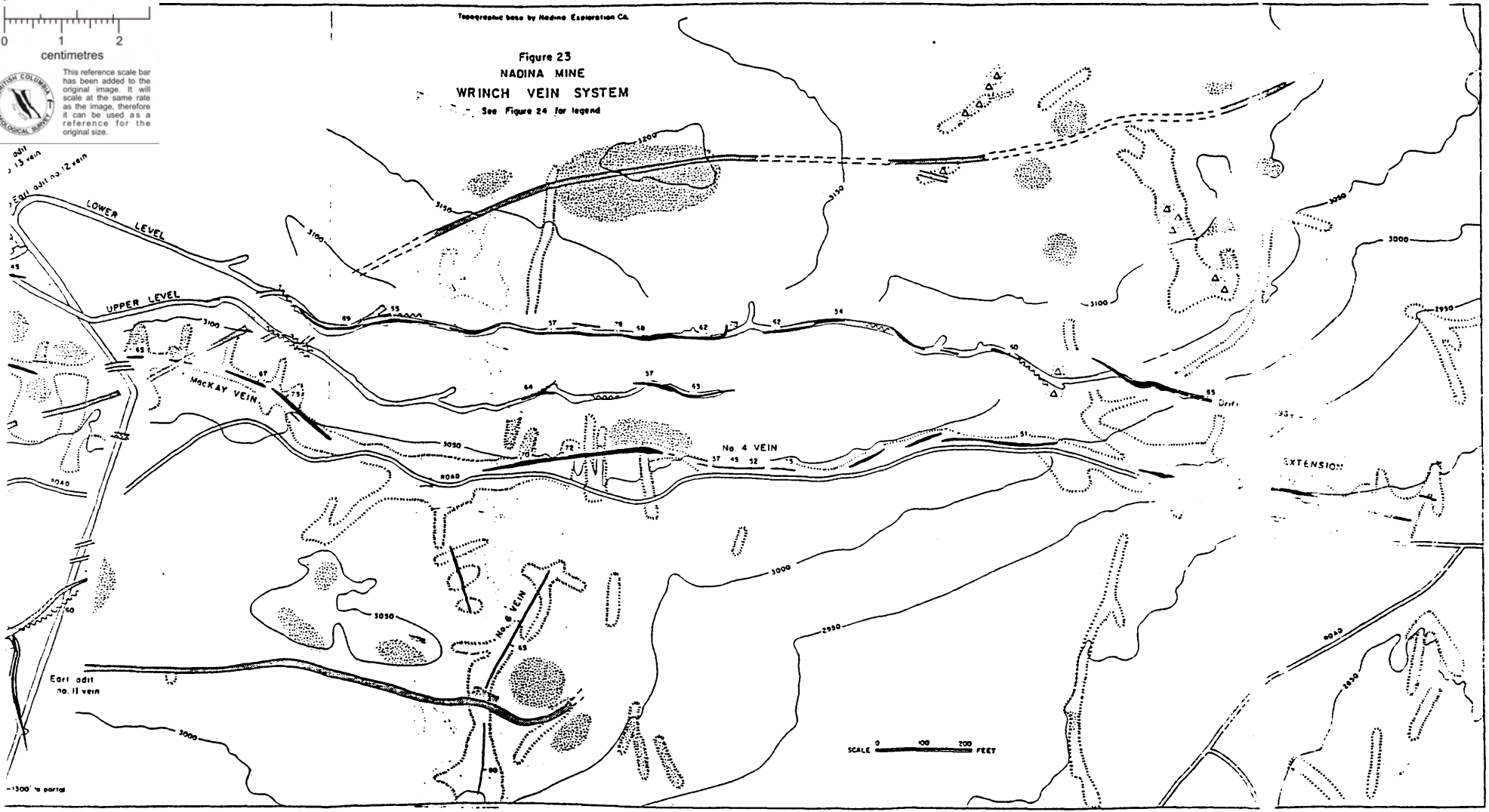
OPERATOR: NADINA EXPLORATIONS LIMITED, 1420, 789 West Pender Street, Vancouver 1.

METALS: Gold, silver, copper, zinc, lead, cadmium.



Topographic base by Nadina Exploration Co.

Figure 23
NADINA MINE
WRINCH VEIN SYSTEM
See Figure 24 for legend



WORK DONE: Geological mapping of the entire property was performed at 1,000 feet to 1 inch and more detailed mapping of the vein system at 100 feet to 1 inch. The property was covered by magnetometer and electromagnetic aerial reconnaissance surveys. A geochemical soil survey was performed on the OL claims, using grid-lines spaced at intervals of 200 feet and sampling at 100-foot spacings along the lines. Diamond drilling included surface work, 31 AQ holes totalling 10,637 feet; and underground work, 20 AQ holes totalling 3,561 feet. About 4,000 feet of drifting was added to existing underground workings. A new compressor building and bunkhouse were installed.

REFERENCES: *Minister of Mines, B.C.,* Ann. Repts., 1916, p. 160; 1923, pp. 114–116; 1924, pp. 99, 100; 1928, pp. 170, 171; 1929, pp. 171–175; 1965, pp. 81–84; 1966, p. 104; 1967, pp. 108, 109; 1968, p. 139; *Geol. Surv., Canada,* Sum. Rept., 1929, pt. A, pp. 62–89; *Geol. Surv., Canada,* Map 671A, Houston; *Geol. Surv., Canada,* Map 971A, Smithers to Fort St. James.

DESCRIPTION:

Introduction

The early history of this property has been reviewed by Holland, 1965. Briefly, the original discovery and initial work were made by Dr. Wrinch and partners in the period 1912 to 1923. The property was then acquired and investigated by the Federal Mining and Smelting Co., 1923 to 1928; the Owen Lake Mining & Development Co. Limited, 1928 to 1941; and Canadian Exploration Limited 1941 to 1963. Nadina Explorations Limited gained control of the property in 1963 by option of 17 Crown-granted claims from Canadian Exploration Limited. Kennco Explorations, (Western) Limited took an option in 1967 but returned the property to Nadina after a geochemical survey and a brief diamond-drill programme. In March, 1970, Northgate Exploration Ltd. obtained an important interest in Nadina.

The extent of workings and known mineralization on the property as of October, 1969, is shown on Figures 23, 24, and 25. Approximately 4,400 lineal feet of vein mineralization is exposed on surface by extensive trenching on Mine Hill and in the Chisholm shaft area. The underground development on Mine Hill consists of two levels totalling about 10,600 feet of crosscuts and drifts which expose about 4,000 feet of veins. Most of the trenching and more than half of the total underground development is the result of work by Nadina.

The main access to the underground workings on the lower level is from the Earl adit crosscut which extends about 3,000 feet northeast from the portal on the west side of Mine Hill at 2,590 feet elevation. Ten drifts branch from the crosscut with a total length of about 5,100 feet. The upper level consists of two main drifts—a northwest drift about 300 feet long and a southeast drift about 2,100 feet long. These are serviced by portals at 2,880 feet elevation in Wrinch Creek canyon. The southeast drift is connected to the Earl adit crosscut by a three-compartment raise.

The Veins

Twenty-three veins are identified and numbered. These consist of the following: Veins Nos. 1 to 3—the original discovery veins in Wrinch Creek canyon; vein No. 4—located several hundred feet southeast of Wrinch Creek canyon beyond the junction of veins Nos. 1 and 2 (the MacKay vein and "Ruby extension" are considered to be part of No. 4 vein); veins Nos. 6 and 7—located several hundred feet south of Wrinch Creek canyon and west of No. 4 vein; the Earl adit veins Nos. 1 to 13, which are veins intercepted by Earl adit crosscut and numbered con-

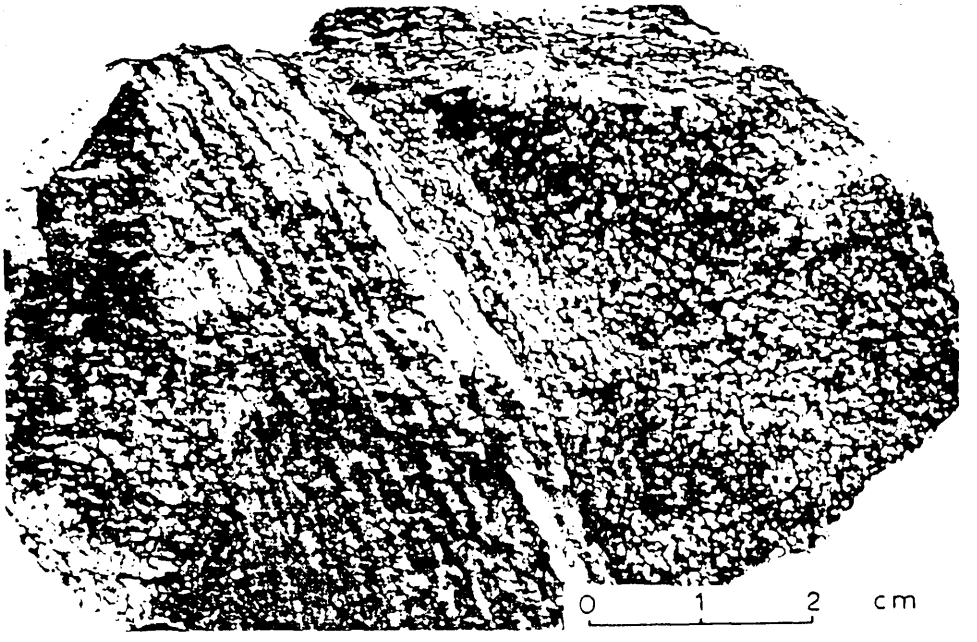


Plate VIA.—Tertiary aquagene tuff from the east fork of Riddeck Creek canyon.

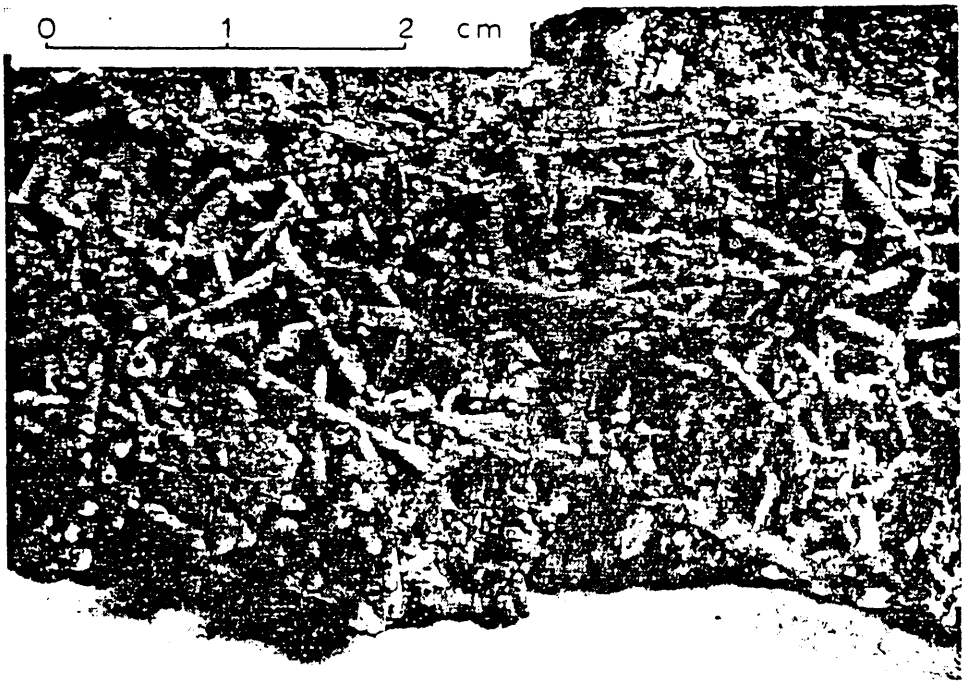


Plate VIB.—Tubular growth of manganese oxide in a vein-cap deposit, vein No. 2 south of Wrinch Creek canyon.

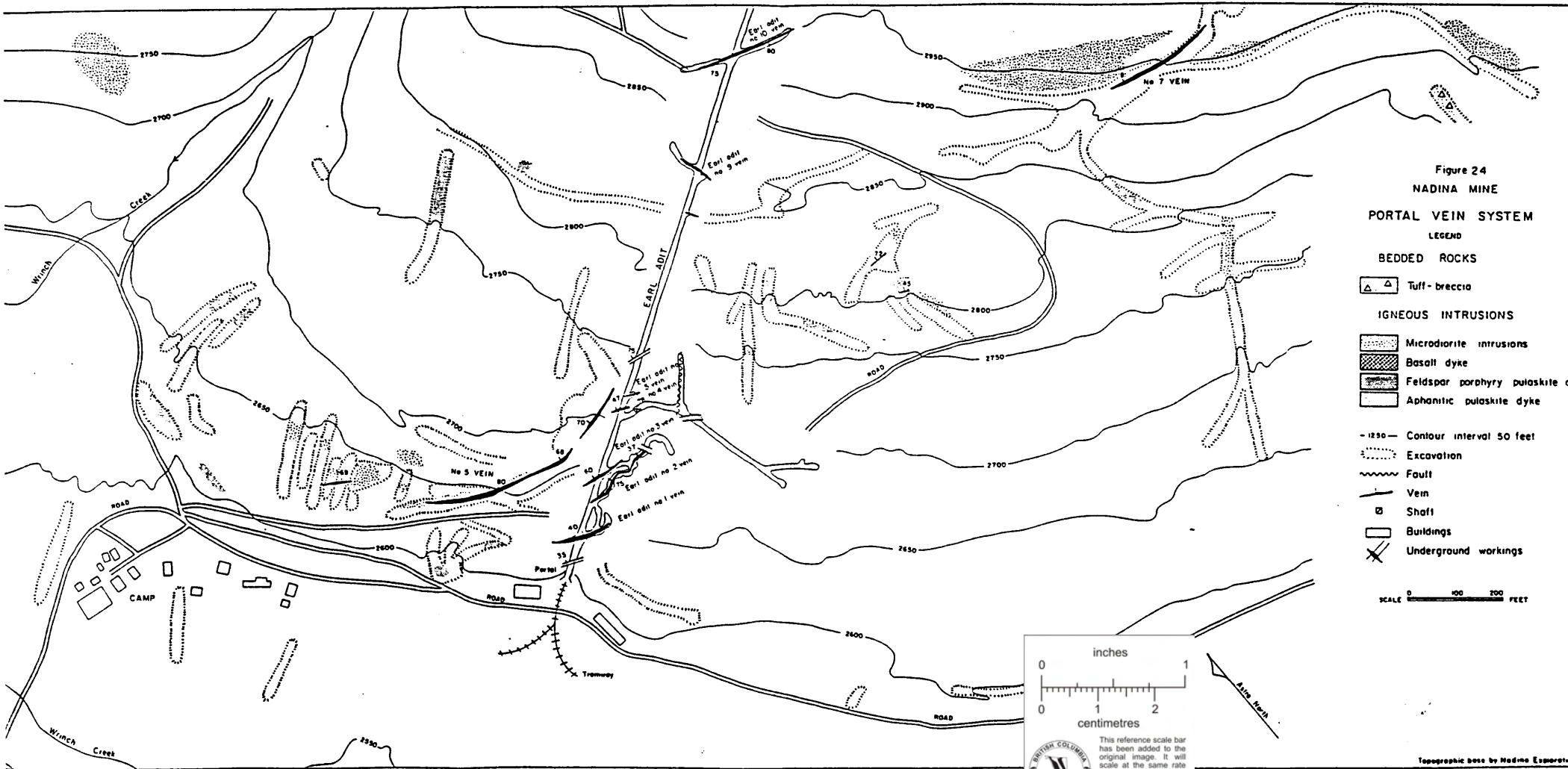


Figure 24
NADINA MINE
PORTAL VEIN SYSTEM
LEGEND
BEDDED ROCKS
Tuff - breccia
IGNEOUS INTRUSIONS
Microdiorite intrusions
Basalt dyke
Feldspar porphyry pulaskite
Aphanitic pulaskite dyke
1250 Contour interval 50 feet
Excavation
Fault
Vein
Shaft
Buildings
Underground workings
SCALE 0 100 200 FEET
EARL ADIT
Earl adit no 10 vein
Earl adit no 9 vein
Earl adit no 5 vein
Earl adit no 4 vein
Earl adit no 3 vein
Earl adit no 2 vein
Earl adit no 1 vein
No 7 VEIN
No 5 VEIN
Portal
CAMP
ROAD
Tramway
Wrinch Creek
Asin Nadin
inches
centimetres
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.
BRITISH COLUMBIA GEOLOGICAL SURVEY
Topographic base by Nadina Exploration

secutively from the portal (three " veins " occurring between Earl adit veins Nos. 5 and 11 are too small to warrant detailed description in this report and are not identified on the plans). Vein No. 5 is located a few hundred feet north of the Earl portal and the Mae Nos. 1 to 3 veins are in the Chisholm shaft area.

Three main groups of veins are currently recognized. These are the " Wrinch vein system," the " Portal vein system," and the " Chisholm vein system."

The Wrinch vein system is the most important and is the site of almost all the current development work (*see* Fig. 23). The system includes veins Nos. 1 to 4, and Earl adit veins Nos. 12 and 13. The average over-all strike of the veins is about 130 degrees. The system can be traced over a length of more than 4,200 feet. Vertical depth from surface exposures of the veins to the Earl adit varies from about 500 to 300 feet, depending on local topography. Most of the veins vary in dip between 50 and 70 degrees northeast, the average dip being 62 degrees on 45 measurements. The veins are generally banded with sphalerite as the predominant sulphide mineral followed by pyrite, chalcopyrite, and then galena. The gangue minerals consist mainly of cherty quartz, carbonate minerals, including rhodochrosite, and some barite.

Vein No. 3 is distinctive with generally a higher chalcopyrite content than the other veins of the system and correspondingly high average copper values (*see* Tabulation of Assays, p. 137). The vein is readily traced and there seems little doubt that Earl adit vein No. 13 is the downward extension of No. 3 to the lower level. In places, pink rhodochrosite is the most important gangue mineral in this vein. An assay of a rhodochrosite slab with pyrite and sphalerite veinlets taken near the face of the north drift on the upper level gives: Gold, 0.03 ounce per ton; silver, 2 ounces per ton; copper, 0.37 per cent; lead, 3.40 per cent; zinc, 3.69 per cent; iron, 10.65 per cent; manganese, 26 per cent; cadmium, 0.02 per cent; arsenic, 0.09 per cent; antimony, 0.05 per cent; bismuth, *nil;* barium, 0.61 per cent.

Vein No. 4 is somewhat discontinuous, being segmented at the northwest and southeast ends into what is known as the " MacKay vein " and " Ruby extension " respectively. Sphalerite and pyrite are the main sulphides; specularite, galena, chalcopyrite, and tennantite are concentrated locally. The ore is generally well banded with seams of grey cherty quartz and some carbonate minerals. Barite occurs locally as randomly oriented plates in vugs and pockets throughout the vein. The Ruby extension contains distinctive red sphalerite (ruby jack) and local concentrations of tennantite.

The average assays for the whole vein show high zinc and fair to good precious metal values (*see* Tabulation of Assays). The Ruby extension has above average gold, silver, and copper content. A sample of coarse sphalerite ore taken 100 feet from the face in the upper level assays: Gold, 0.04 ounce per ton; silver, 2.1 ounces per ton; copper, 0.89 per cent; lead, 0.14 per cent; zinc, 35.93 per cent; iron, 5.56 per cent; manganese, 0.24 per cent; cadmium, 0.24 per cent; arsenic, 0.33 per cent; antimony, 0.10 per cent; bismuth, less than 0.01 per cent; barium, 0.01 per cent. A sample of colloform-banded sphalerite-rich ore taken near the northwest end of the Ruby extension on the lower level assays: Gold, 0.34 ounce per ton; silver, 42.8 ounces per ton; copper, 0.19 per cent; lead, 1.60 per cent; zinc, 28.20 per cent; iron, 5.40 per cent; manganese, 0.40 per cent; cadmium, 0.12 per cent; arsenic, 0.14 per cent; antimony, 0.02 per cent; bismuth, less than 0.01 per cent; barium, 3.24 per cent. Analysis of a vuggy pyrite, red sphalerite, rich ore sample from the Ruby extension taken at the face on the lower level shows: Gold, 0.76 ounce per ton; silver, 21.4 ounces per ton; copper, 0.13 per cent; lead, 7.05 per

cent; zinc, 31.50 per cent; iron, 7.58 per cent; manganese, 0.12 per cent; cadmium, 0.17 per cent; arsenic, 0.50 per cent; antimony, 0.02 per cent; bismuth, 0.01 per cent; barium, 4.66 per cent.

Vein No. 2 may be the northwest extension of No. 4 and their downward extension is probably Earl adit vein No. 12; all three veins being relatively poor in chalcopyrite compared to nearby vein No. 3. Vein No. 2 and Earl adit vein No. 12 are similar in having only moderate precious metal values (*see* Tabulation of Assays).

Vein No. 1 is the most westerly vein of the Wrinch system. The copper-lead-zinc values are similar to those of the Ruby extension of vein No. 4; however, precious metal grades are comparatively low (*see* Tabulation of Assays).

The Portal vein system contains some of the most spectacular metal grades to be found on the property. The ore reserve in this system, however, appears to be relatively small at the present stage of mine development. This is due to the position of the veins near the portal of the lower level where backs are generally less than 100 vertical feet from surface (*see* Fig. 24). The system includes vein No. 5 and Earl adit veins Nos. 1 to 5. Like the Wrinch system, the veins generally dip to the northeast; however, they strike more easterly than do the Wrinch veins.

Vein No. 5 is exposed at intervals on surface over a length of 500 feet. It is typically chalcopyrite-rich and carries above-average precious metal values (*see* Tabulation of Assays). A quartz-chalcopyrite sample was assayed with the following results: Gold, 0.28 ounce per ton; silver, 24.2 ounces per ton; copper, 7.19 per cent; lead, 0.17 per cent; zinc, 0.17 per cent; iron, 11 per cent; manganese, 0.34 per cent; cadmium, *nil;* arsenic, *nil;* antimony, *nil;* bismuth, 0.11 per cent; barium, 0.01 per cent.

Earl adit veins Nos. 1 to 5 are not exposed on surface but have been intercepted in underground workings in the area immediately south of vein No. 5. Earl adit veins Nos. 1 to 3 are subparallel and are 90 feet, 180 feet, and 230 feet respectively from the portal in the Earl adit crosscut. Earl adit vein No. 1 is chalcopyrite-rich and similar to vein No. 5, whereas Earl adit vein No. 2 is richer in sphalerite and contains lower precious metal values (*see* Tabulation of Assays); No. 3 is pyritiferous, with generally low metal values.

Earl adit veins Nos. 4 and 5 are approximately 375 feet and 400 feet respectively from the portal. These are narrow and discontinuous and metal grades are low to moderate. The veins do not appear to be related to vein No. 5 which is exposed almost directly above on surface.

Veins Nos. 6 and 7 and Earl adit veins Nos. 9 to 11 are between the Wrinch vein system and the portal vein system.

Nos. 6 and 7 are exposed on the surface a few hundred feet west of the midpoint on vein No. 4 (*see* Figs. 23 and 24). These strike easterly and appear to be interconnected. Sphalerite and pyrite are the most important sulphides, galena and chalcopyrite are accessory, the veins being compositionally similar to vein No. 4 of the Wrinch system.

Earl adit veins Nos. 9 to 11 are intersected in Earl adit crosscut approximately 910 feet, 1,150 feet, and 1,440 feet respectively from the portal. No. 10 strikes about 105 degrees and dips steeply to the south. The vein can be traced for about 200 feet in drifts branching east and west from the main crosscut. Unlike veins Nos. 6 and 7, Earl adit vein No. 10 is chalcopyrite-rich; however, these veins are subparallel and possibly lie on the same curving fracture system.

Earl adit veins Nos. 9 and 11 are unusual because of their northerly trend. No. 9 is a pyrite-sphalerite vein exposed in north and south stub drifts branching

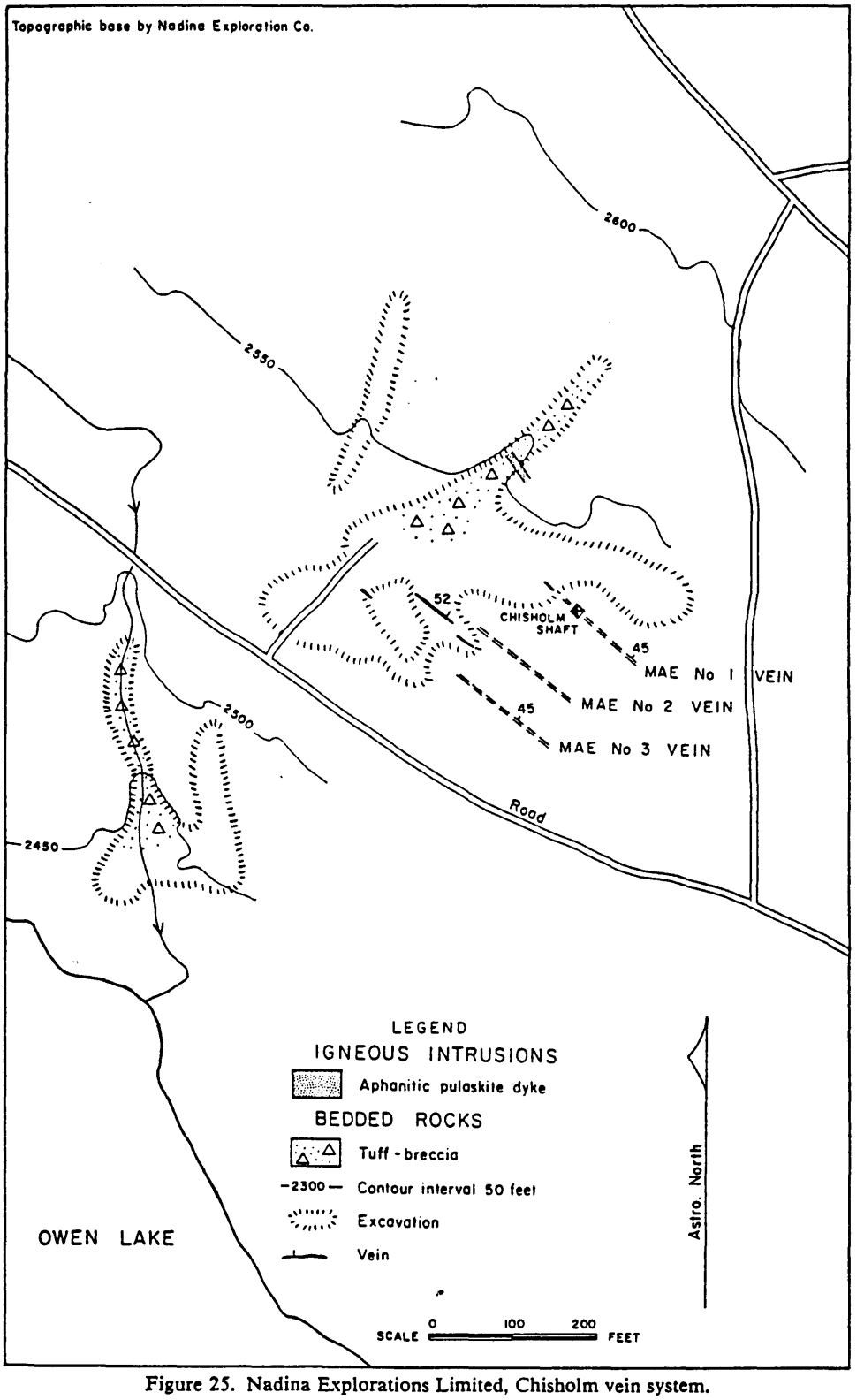


Figure 25. Nadina Explorations Limited, Chisholm vein system.

from the main crosscut. The vein is discontinuous and lens-like but measures 3 feet wide in places. A well-banded section strikes 160 degrees and dips 78 degrees southwest.

Earl adit vein No. 1 is traced approximately 180 feet in a north-branching drift. The vein is generally steeply dipping and somewhat sinuous in strike. The mineralogy is variable and in places the vein is composite, consisting of pyrite-chalcopyrite and sphalerite-galena phases. Near the north end of the drift the vein terminates against a feldspar-porphyry trachyte dyke.

The Chisholm vein system consists of three subparallel veins—Mae vein No. 1, Mae vein No. 2, and Mae vein No. 3, located about 4,000 feet south of Mine Hill. These are now poorly exposed but can be traced 150 to 200 feet along strike in a series of old trenches and a few new excavations (*see* Fig. 25). The veins strike about 125 degrees and dip northeasterly. The minerals are mainly argentiferous sphalerite and galena, pyrite; chalcopyrite is scarce. The host rocks consist of highly altered dacitic tuffs and tuff breccias.

A newly discovered vein, compositionally similar to the veins of the Chisholm system, is about 3,500 feet southeast of Earl adit portal midway between the Wrinch and Chisholm vein systems. The vein is 3 feet wide and strikes southeasterly. An assay of a grab sample containing fine-grained sphalerite, galena, pyrite, barite, and cherty quartz shows: Gold, 0.24 ounce per ton; silver, 6.5 ounces per ton; copper, 0.11 per cent; lead, 5.56 per cent; zinc, 16.55 per cent; iron, 5.20 per cent; manganese, 1.56 per cent; cadmium, 0.10 per cent; arsenic, *nil;* antimony, 0.05 per cent; bismuth, *nil;* barium, 6.96 per cent.

Mineralization

The veins are mainly the result of fissure-filling. This is proved by their vuggy structure and the colloform banding of the ore minerals and gangue. The exact amount of dilation of fissures prior to mineralization is difficult to estimate owing to the partial replacement of wallrocks by pyrite and other vein minerals; however, the average width of the veins is 3 to 4 feet, increasing to as much as 15 feet locally.

At least four distinctive mineral assemblages are recognized. These are, as follows, in approximate order of deposition:—

(1) Pyrite, specularitic hematite.
(2) Sphalerite (ruby jack), pyrite, galena, tennantite.
(3) Chalcopyrite, pyrite, sphalerite, bismuthinite(?), tetrahedrite(?).
(4) Sphalerite (amber), pyrite, galena.

The gangue constituents are mainly cherty quartz, carbonate minerals such as rhodochrosite and siderite, some barite, and rarely pyrobitumen. These assemblages occur as single veins or more commonly as lenses and layers in composite veins.

The veins show a rough zonal arrangement. The Wrinch and portal vein systems in the Mine Hill area are composite, reflecting a history of pulsating mineralization with many changes in the temperature and composition of the hydrothermal solutions. On the other hand, in outlying areas such as near Cole Lake and the Chisholm shaft, the veins are uniformly carrying the low-temperature assemblage, sphalerite-pyrite-galena.

The ratio of gold to silver for most veins is in the range of 3:1000 to 10:1000. Highest precious metal values are commonly in chalcopyrite-pyrite ores, such as vein No. 5 and Earl adit vein No. 1, and sphalerite-rich ores containing accessory tetrahedrite or tennantite, such as the Ruby extension of vein No. 4. The re-

sults of X-ray and spectrographic analyses of a sample of tennantite from the Ruby extension are given in a table on page 139. The slightly larger than normal cell edge of the tennantite suggest that it is an argentiferous variety.

The composition of sphalerite shown by 22 spectrographic analyses reveals moderately high cadmium content, in the range 0.20 to 1.20 per cent. The cell edge of these sphalerites determined from X-ray analyses is small, 5.406 angstroms. This is in agreement with low-average iron content, 0.96 per cent (maximum, 3.50 per cent), and low manganese, a trace to 0.10 per cent.

Local intense alteration of wallrocks accompanies the veins and adjacent fissures. The lateral extent of the alteration zones is variable, ranging from several feet to tens of feet in breadth. Typically, the altered rocks are cream coloured and soft and have low magnetic susceptibility. At surface the veins are usually capped by a compact black deposit of manganese oxide (*see* Plate VIB). In the microdiorite, the plagioclase phenocrysts are evident as small greenish laths and plates. Thin-section studies show that the altered rocks consist of a mixture of clay and carbonate mineral, some chlorite, and minor epidote, and disseminated pyrite. Also, chemical analyses show that important iron and magnesium metasomatism is attendant to the alteration (*see* Table of Chemical Analyses, p. 138).

Widespread alteration is also present. The affected country rock is mainly volcanic breccia exposed within a 1½-mile radius of Mine Hill. The alteration is manifested in the development of numerous limonite and jarosite gossans and appears to be the result of pervasive kaolinization pyritization. It is considered that the extent of this alteration is greater than would normally be associated with the emplacement of the known vein systems. A deep and broad source of mineralizing solutions is suspected and the discovery of replacement-type sulphide bodies appears to be a possibility.

A statistical study of the geochemical data from five widely spaced Kennco-Nadina diamond-drill holes provides ancillary information on the mineralogy of the altered country rock remote from the vein systems (*see* the position of diamond-drill holes K1 to K5 on Figure 21). Most of the core from these holes is known to contain at least some disseminated pyrite and local concentrations of dark sphalerite specks; however, other sulphides were not readily identified. The product moment correlation coefficients calculated for silver, copper, zinc, and iron from the five holes are given in the Table of Correlation Coefficients on page 138. Examination of these data from hole K4 shows remarkably good frequency correlation between iron, copper, and silver. This is interpreted as indicating the presence of argentiferous chalcopyrite in the core. Similarly, in hole K3, a correlation is found between copper and silver which may indicate tetrahedrite. Other correlations are found in hole K2 between silver and zinc and in hole K1 between silver and copper, and a negative correlation between copper and iron.

The age of the vein mineralization is thought to be Eocene or at least Early Tertiary. This is indicated by the relationship of the veins to the Ootsa-type feldspar-porphyry trachyte dykes and fine-grained pulaskite dykes on Mine Hill. The feldspar-porphyry dykes are coincident with the initial phase of mineralization and clearly pre-date the main episodes of vein-filling; however, the vein fissures were open and had already received some pyritiferous solutions before these dykes were emplaced. This is demonstrated by vein No. 6 and Earl adit vein No. 11 (*see* Fig. 23). These veins terminate abruptly against the same steeply dipping feldspar-porphyry dyke. In both cases, however, small pyrite-bearing leads are traced be-

yond the dyke on the face opposite the main vein, proving the pre-dyke origin of the vein fissure system. The pulaskite intrusions post-date most of the mineralization. This is well displayed on the lower level of the mine where a pulaskite dyke has intruded the west part of vein No. 4, splitting and crosscutting the vein in several places and running parallel to it for a distance of about 1,000 feet. Similarly, pulaskite dykes and sills were found intruding vein No. 3 on the upper level and Earl adit veins No. 2 and No. 12.

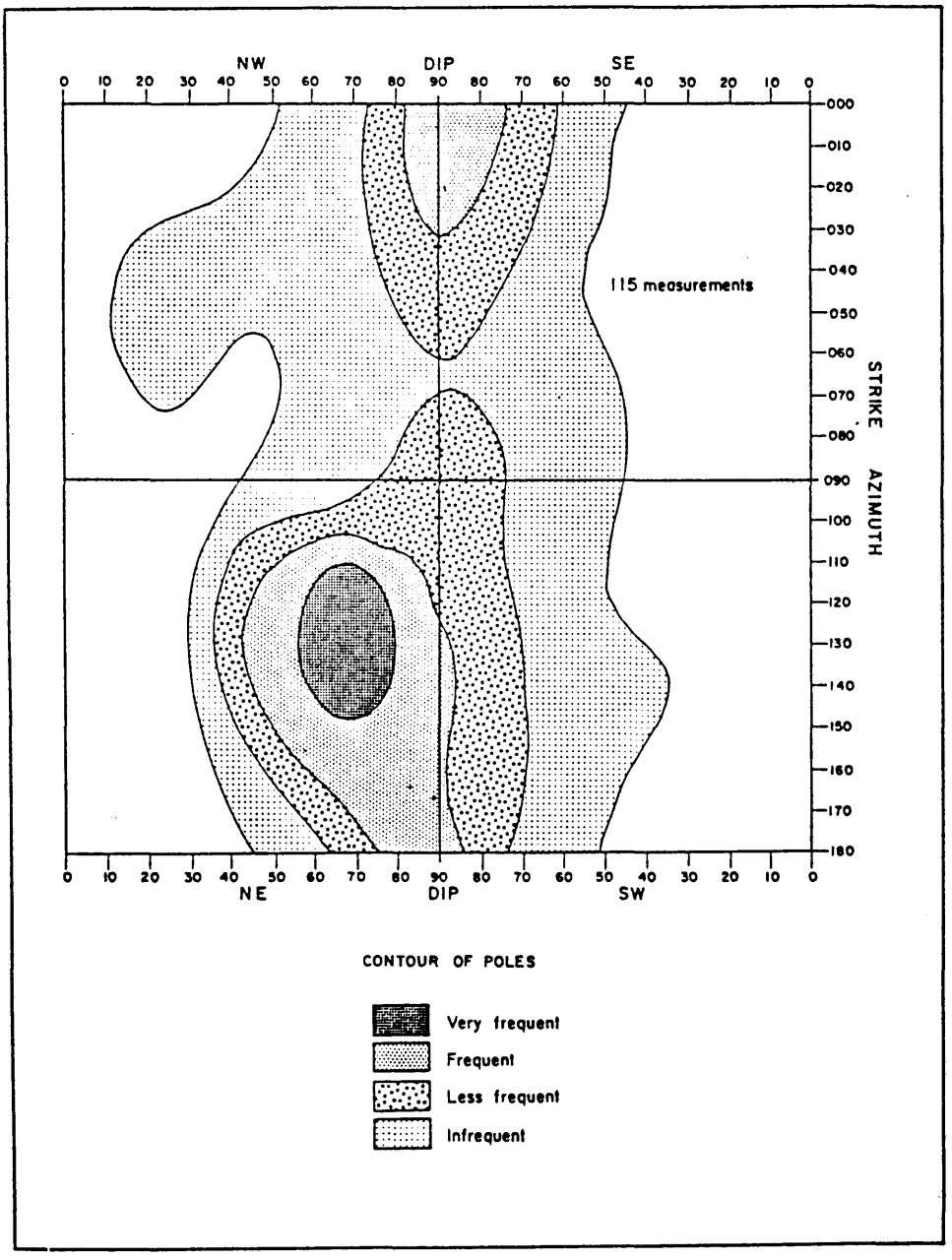


Figure 26. Nadina Explorations Limited, plot of fractures, Mine Hill area.

Structure

The attitude and frequency of fractures in the Mine Hill area is shown on Figure 26. The strongest joints strike about 130 degrees and dip 68 degrees northeast. This attitude coincides with prominent topographic lineaments, the main vein directions and shears. Other strong fractures strike northerly and dip steeply to the east. Weak fractures include cross-joints striking east and dipping steeply, and sheeting joints which strike about 050 degrees and dip 25 degrees northwest.

A study of slickensides reveals the attitude and direction of movement on faults and shear planes. An equal area plot of slickensides shows two important

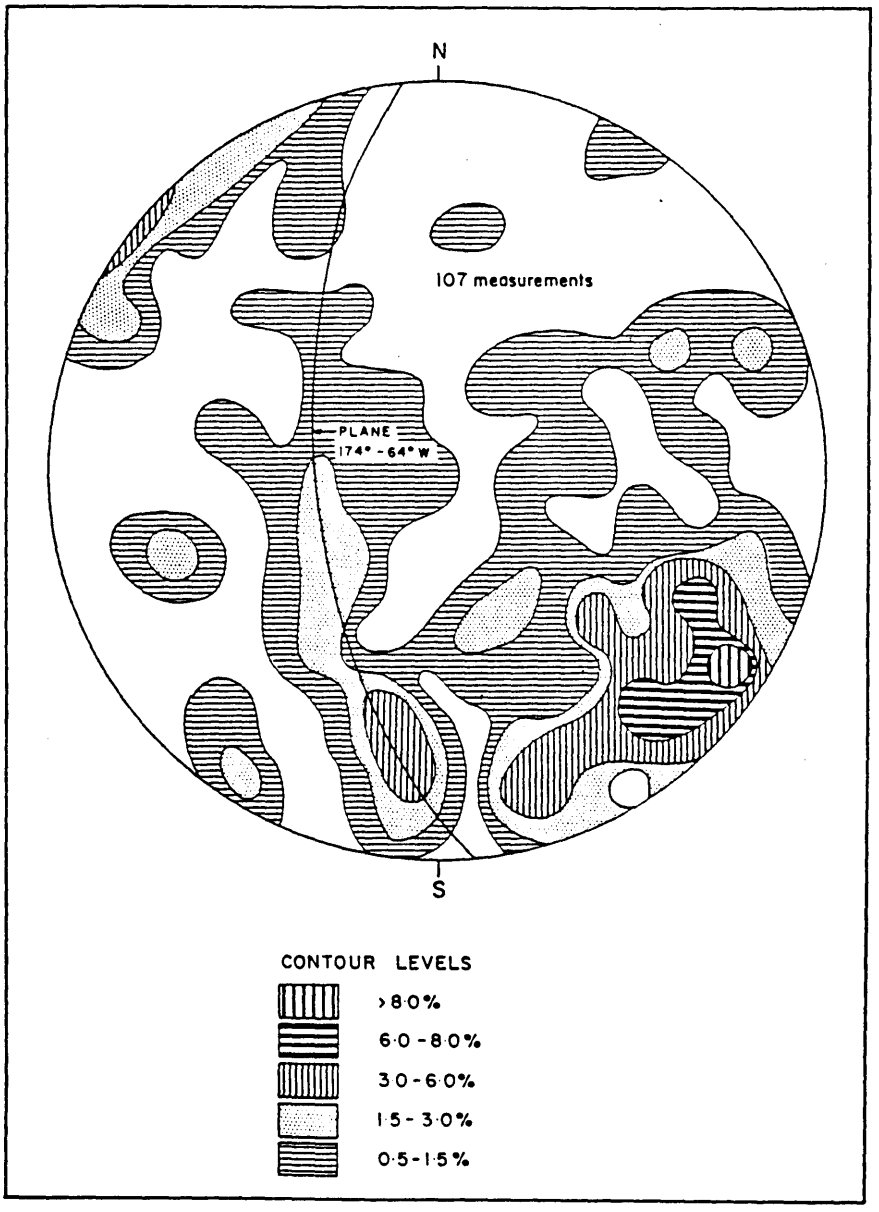


Figure 27. Nadina Explorations Limited, equal area diagram of slickenside attitudes, Mine Hill area.

directions in the Mine Hill area, a strong slickenside polarization at strike 123 degrees plunge 12 degrees southeast and a weaker polarization at 190 degrees plunge 30 degrees south (*see* Fig. 27). The angular distance between these slickenside poles is 60 degrees. This indicates that the maximum stress axis responsible for the formation of these structures must have had a strike orientation of approximately 150 degrees plunge 25 degrees southeast. This geometry suggests that many steep northerly striking fractures in the Mine Hill area have sinistral strike-slip displacement, whereas movement on steep southeasterly striking fractures is dextral; tension fractures are contained between these shears. The dispersion of slickenside poles about the plane striking 174 degrees, dipping 64 degrees west indicates that this is a common fault direction containing strong strike-slip displacement, together with some reverse or normal movement.

Much of the post-mineralization faulting in the Mine Hill area appears to be of a minor nature. This is evident from the marked continuity of the feldspar-porphyry trachyte dyke system (*see* Fig. 23). These dykes are readily traced on surface and through the underground workings. The maximum observed fault displacement is near the west end of vein No. 4 on the upper and lower levels of the mine where a feldspar porphyry dyke is offset about 50 feet on a steeply dipping tear fault. Shearing and faulting in Wrinch Creek canyon clearly predates the dykes and veins. Both basalt and feldspar porphyry dykes are known to traverse the canyon with little or no offset.

The general pattern of the vein systems is not fully understood; however, it is thought that the main veins are fillings of northwesterly trending tension fractures and replacements along northerly trending shears developed in response to the stress geometry described above. Most of the veins on the Nadina property are the former type, with a number of modifications. For example, veins Nos. 1 to 3 in the Wrinch vein system appear to form part of a " cymoid loop." These veins strike subparallel in the area northwest of Wrinch Creek and converge in the area to the southeast. Veins Nos. 4, 6, and 7 are arranged in a pattern best described as a " chatter link." Vein No. 4 is through-going and strikes southeasterly, roughly parallel to vein No. 7. Vein No. 6 and a subsidiary branching vein continue on the same fissure system as vein No. 7 but strike sharply toward vein No. 4, forming a cross connection. The portal system forms what appears to be a tight in echelon series of overlapping but unconnected vein lenses. This pattern is incomplete; however, this may be due to poor exposure in the area.

Most of the vein systems on the Nadina property are open at both ends and much additional surface and underground exploration work is required before an adequate structural synthesis can be fully realized.

Tabulation of Assays

Vein System	Vein	Location	Samples			Gold	Silver	Copper	Lead	Zinc	Source of Data
			Number	Length	Average Width						
				Ft.	Ft.	Ounce/Ton	Ounce/Ton	Per Cent	Per Cent	Per Cent	
Wrinch	No. 1	Surface	4	600	6.7	0.02	6.3	0.66	1.6	5.3	B.C. Ann. Rept., 1965.
Wrinch	No. 2	Surface	12	1,200	6.4	0.02	2.8	0.1	4.3	6.2	B.C. Ann. Rept., 1965.
Wrinch	No. 3	Upper level, south drift	Numerous	560	3.4	0.07	7.8	2.77	0.81	6.7	Nadina Ann. Rept., 1969.
Wrinch	No. 3	Upper level, north drift	Numerous	50	3.0	0.05	6.1	2.55	0.21	0.96	Nadina Ann. Rept., 1969.
Wrinch	No. 4	Surface	Numerous	1,000	4.0	0.17	10.1	0.2	2.8	5.6	Nadina Ann. Rept., 1969.
Wrinch	No. 4 (MacKay vein)	Surface	5	300	4.8	0.06	5.9	0.14	4.3	7.7	B.C. Ann. Rept., 1965.
Wrinch	No. 4	Upper level	Numerous	204	6.5	0.11	6.46	0.33	2.39	6.93	Nadina Ann. Rept., 1969.
Wrinch	No. 4	Earl adit-level	Numerous	848	5.0	0.08	7.5	0.45	1.8	7.9	Nadina Ann. Rept., 1969.
Wrinch	No. 4 (Ruby extension)	Earl adit-level	Numerous	620	4.0	0.19	16.0	0.68	1.8	5.9	Nadina Ann. Rept., 1969.
Portal	No. 5	Surface	17	210	2.5–3	0.078	26.71	5.55	0.33	2.68	Nadina records; press release, November, 1969.
Portal	No. 5	Surface	8	110	3.8	0.22	29.45	3.57	0.21	0.73	Nadina records; press release, November, 1969.
Unclassified	No. 6	Surface	Several	250	3.5	0.13	3.4	0.37	2.20	6.40	Nadina records.
Unclassified	No. 6 (north branch)	Surface	....	.....	3.7	0.10	3.0	0.11	2.10	10.20	Nadina records.
Unclassified	No. 7	Surface	....	.....	3.0	0.07	4.8	0.93	2.00	8.44	Nadina records.
Portal	Earl adit No. 1	Earl adit	30	80	5.0	0.12	26.5	2.57	0.82	5.28	Old company records.
Portal	Earl adit No. 2	Earl adit	22	150	3.5	0.04	5.7	0.60	0.47	7.06	Old company records.
Portal	Earl adit No. 3	Earl adit	4	30	3.5	0.01	1.5	0.5	0.6	5.2	Old company records.
Portal	Earl adit No. 4	Earl adit	7	.....	1.8	0.01	1.5	0.1	0.16	3.5	Old company records.
Portal	Earl adit No. 5	Earl adit	5	.....	0.8	0.01	3.56	0.8	0.38	5.1	Old company records.
Unclassified	Earl adit No. 9	Earl adit	....	.....	---	.....	3.8	0.63	1.2	4.0	Old company records.
Unclassified	Earl adit No. 10	Earl adit	....	200	1.5	.....	4.0	1.6	0.9	1.2	Old company records.
Unclassified	Earl adit No. 11	Earl adit	5	220	2.0	0.04	8.2	1.2	0.56	1.4	Old company records.
Wrinch	Earl adit No. 12	Earl adit	9	30	9.4	0.02	3.76	0.3	3.3	9.6	B.C. Ann. Rept., 1965.
Wrinch	Earl adit No. 13	Earl adit	4	250	7.5	0.04	5.7	2.5	1.7	8.0	Nadina records.
Wrinch	Earl adit No. 13 north splay	Earl adit	3	70	1.4	0.05	12.05	7.01	0.72	4.02	Consultant's report to Nadina, 1965.
Chisholm	Mae No. 1	Shaft	2	Spot	1–2	0.10	9.6	0.16	2.08	16.6	Nadina records.
Chisholm	Mae No. 2	Surface	3	100	2.3	0.09	22.47	.....	9.2	2.5	Old company records.
Chisholm	Mae No. 3	Surface	5	270	3.5	0.03	5.7	.....	1.9	6.7	Old company records.

Correlation Coefficients "R" Calculated for Geochemical Results from Kennco-Nadina Diamond-drill Holes Nos. 1 to 5

Diamond-drill Holes	Ag		Zn		Cu		
	Arithmetic	Logarithmic	Arithmetic	Logarithmic	Arithmetic	Logarithmic	
K1	−0.250	−0.255	−0.202	−0.304	−0.411	−0.408	
K2	0.450	0.294	0.172	0.218	0.023	−0.020	
K3	0.028	0.029	0.239	0.317	−0.161	−0.087	Fe
K4	0.894	0.791	0.299	0.537	0.742	0.663	
K5	−0.104	−0.032	0.225	0.384	0.128	0.134	
K1			0.097	0.073	−0.102	−0.096	
K2			0.441	0.631	−0.039	0.114	
K3			0.219	0.366	0.563	0.528	Ag
K4			0.102	0.252	0.739	0.875	
K5			−0.023	0.108	−0.333	−0.299	
K1					0.455	0.722	
K2					0.023	0.278	
K3					0.368	0.426	Zn
K4					0.376	0.453	
K5					0.254	0.263	

Number of samples K1, 28; K2, 29; K3, 16; K4, 11; K5, 37.

Formula: $$R = \frac{\Sigma(x)(y) - (\Sigma x \Sigma y)/n}{\sqrt{(\Sigma x^2 - (\Sigma x)^2/n)(\Sigma y^2 - (\Sigma y)^2/n}}$$

R = 1 for perfect correlation.

R = 0 for no correlation.

Data calculated from computer programme designed by W. J. McMillan, Mineralogical Branch, British Columbia Department of Mines and Petroleum Resources.

Table of Chemical Analyses

	1	2	3	4
SiO_2	57.92	57.50	57.59	45.55
TiO_2	0.74	0.79		
Al_2O_3	17.74	17.33	18.83	16.92
Fe_2O_3	3.10	3.78	6.67	16.92
FeO	2.84	3.62		
MnO	0.18	0.22		
MgO	1.40	2.86	1.98	6.71
CuO	6.13	5.83	5.03	1.74
Na_2O	3.61	3.53		
K_2O	3.25	2.36		
BaO	0.18			
P_2O_5	0.22	0.30		
SO_3	0.07			
H_2O+	2.28	1.88		
H_2O-	0.11			
CO_2	0.11			

KEY TO TABLE OF CHEMICAL ANALYSES

1. Analysis of fresh microdiorite from Wrinch Creek area; analysis by S. Metcalfe, British Columbia Department of Mines and Petroleum Resources.
2. Average composition of augite andesite by Daly (1933); Table 1 Average Compositions, No. 50, p. 16.
3. Partial analysis of fresh microdiorite from surface, Owen Lake mine; analysis No. 1, p. 79A, Lang (1929).
4. Partial analysis of propylitized microdiorite, Owen Lake mine, analysis No. 2, p. 79A, Lang (1929).

X-ray Data on Tennantite

I	d	$Sin^2\phi$	(L k l)
4	4.164	.03422	211
1	3.656	.04439	220
5	3.308	.05421	310
1	3.084	.06239	---
10	2.926	.06932	222
2	2.725	.07987	321
5	2.538	.09211	400
3	2.394	.10352	330
1	2.272	.11496	420
1	2.082	.13637	422
4	1.998	.14858	510
1	1.903	.16380	---
4	1.859	.17163	521
10	1.801	.18298	440
1	1.746	.19460	530
2	1.653	.21720	611
1	1.623	.22517	620
9	1.537	.25121	622
2	1.473	.27349	444
2	1.440	.28604	711
2	1.371	.31568	642
2	1.277	.36364	800
1	1.256	.37629	733
1	1.220	.39842	653

Cell edge calculated from $Sin^2\phi$ values, 10.25 angstroms.
Spectrographic results:—

Per Cent	Per Cent
Fe — 5.	As — more than 10.
Cu — major constituent.	Sb — 5.
Pb — 1.5.	Cd — 0.3.
Zn — more than 10.	Ag — present.

DIAMOND BELLE (No. 907, Fig. 13)

By B. N. Church

LOCATION: Lat. 54° 06′ Long. 126° 42′ (93L/2E)
Adjoins the Nadina property on the northeast.

CLAIMS: Twenty-two claims, including DIAMOND BELLE, BLACK BEAR, ETHEL, IVAN FR., VAN 1 to 9, VAN No. 1 FR., BELL 1 to 3, BELL No. 1 to 5 FR.

ACCESS: The property is about 30 miles south of Houston on a good gravel road.

OWNER: FRONTIER EXPLORATION LIMITED, 642 Clark Drive, Vancouver 6.

METALS: Silver, lead, zinc, copper.

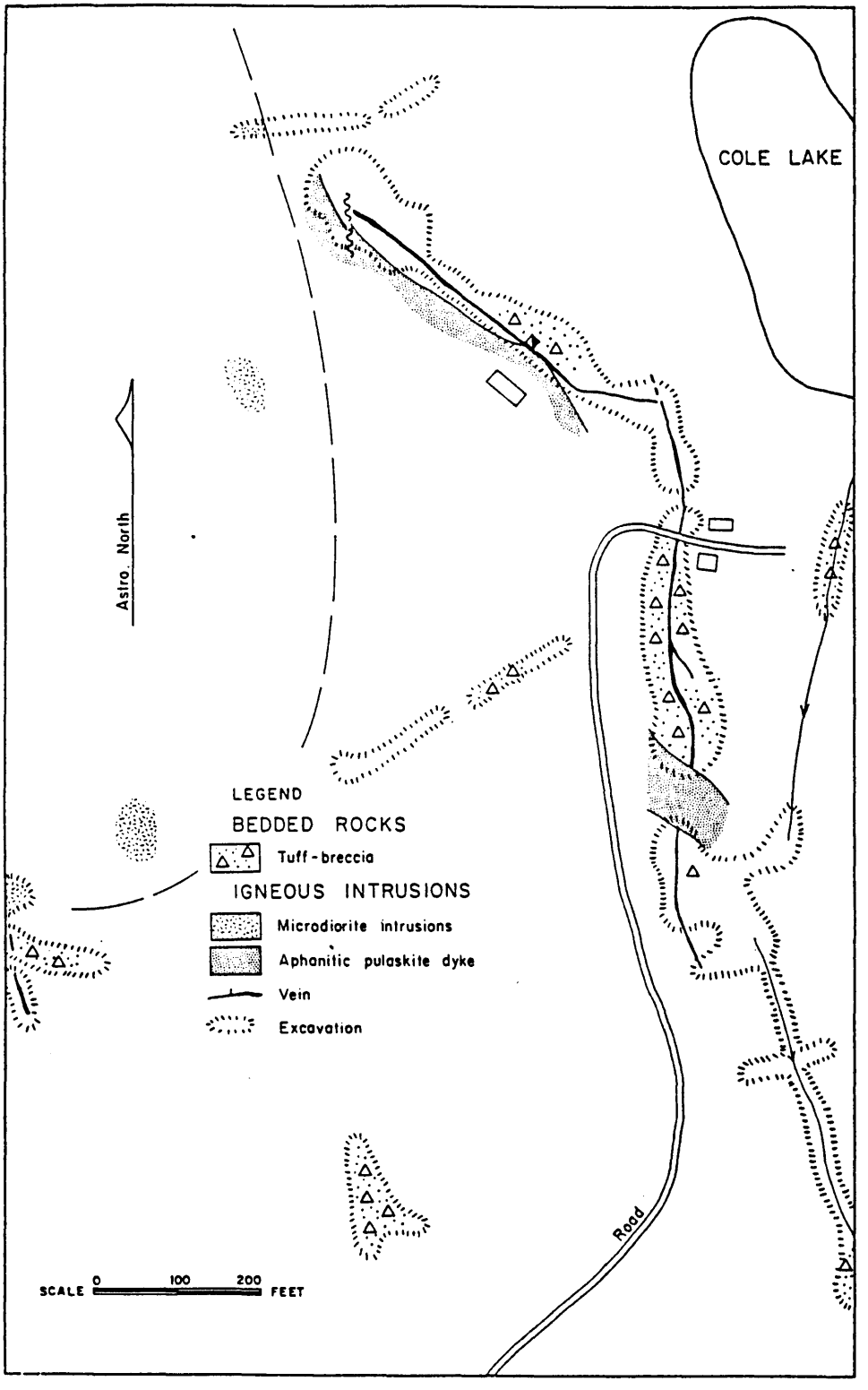
WORK DONE: An aeromagnetic reconnaissance survey of the entire property was performed.

REFERENCES: *Minister of Mines, B.C.*, Ann. Repts., 1916, pp. 144, 159; 1923, pp. 114, 116; 1925, p. 142; 1927, p. 139; 1928, p. 170; 1966, p. 104.

DESCRIPTION:

Introduction

The history of the Diamond Belle property closely parallels that of the Silver Queen. The original claims were located by Mr. Cole and partners in 1915 in an area of vein mineralization northeast of the Silver Queen claim and immediately west of a shallow pond now known as Cole Lake (*see* Fig. 21). The Owen Lake



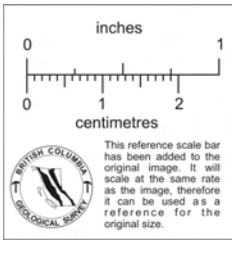


Figure 28. Frontier Exploration Limited, Cole vein system.

Mining and Development Co. obtained control of the ground in 1928 and sank an 80-foot-deep shaft on the main vein. The next significant period of activity began when Frontier Exploration Limited acquired the holdings in 1966. The work of this company, which includes diamond drilling and extensive trenching, has revealed some important new mineralization.

Geology

The general setting of the Cole vein system is shown on Figure 28. The system consists of two main veins, the Diamond Belle vein and the " shear vein." The Diamond Belle vein has been the focus of most of the early exploration, the Cole shaft being located on this vein at a point about 250 feet west of Cole Lake. The vein averages 2 to 3 feet wide and strikes about 130 degrees over the central part; the southeasterly part swings in an easterly direction before pinching out and the northwest segment is deflected along the east contact of a pulaskite dyke which strikes about 150 degrees. The vein is generally well banded with some colloform structures which probably formed as a result of fissure-filling. The ore minerals are mainly sphalerite, galena, and pyrite, with accessory chalcopyrite and a gangue composed of cherty quartz, carbonate minerals such as rhodochrosite, and some barite. According to published assay results (press release, April, 1969), the composition of this vein over a length of 600 feet and an average width of 2.8 feet is as follows: Gold, 0.01 ounce per ton; silver, 2.5 ounces per ton; copper, 0.20 per cent; lead, 3.2 per cent; zinc, 2.8 per cent.

The so-called " shear vein " was recently uncovered near the east end of the Diamond Belle vein about 150 feet west of Cole Lake. This vein is steeply dipping like the Diamond Belle vein, but strikes in a northerly direction. The vein is exposed at intervals for a length of about 700 feet. The mineralization is patchy and discontinuous and appears to be the result of replacement and cavity-filling in a shear zone. According to published statements (press release, April, 1969), the vein averages 6.3 feet wide for a selected 400-foot length and contains gold, 0.13 ounce per ton; silver, 8.8 ounces per ton; copper, 0.45 per cent; lead, 3.3 per cent; zinc, 3.4 per cent.

The host rocks consist of kaolinized and pyritized dacitic volcanic breccia. The Mine Hill microdiorite sill crops out a few hundred feet to the west of the major veins and a pulaskite dyke strikes northwesterly through the area cutting the shear vein and the extreme north end of the Cole vein.